

## CMOS ANALOG MULTIPLEXERS/DEMULTIPLEXERS

### FEATURES

- ◆ Wide Range of Digital and Analog Signal Levels:  
Digital-3 to 15V, Analog-to 15V<sub>p-p</sub>
- ◆ Low ON-Resistance: 80Ω (typ.) over entire 15V<sub>p-p</sub> Signal-Input Range for V<sub>DD</sub>-V<sub>EE</sub> = 15V
- ◆ High OFF-Resistance: Input Leakage ± 10pA (typ) @ V<sub>DD</sub>-V<sub>EE</sub> = 10V
- ◆ Logic-Level Conversion for Digital Addressing Signals of 3 to 15V (V<sub>DD</sub>-V<sub>SS</sub>= 3V to 15V) to Switch Analog Signals to 15V<sub>p-p</sub> (V<sub>DD</sub>-V<sub>EE</sub> = 15V)
- ◆ Matched Switch Characteristics: ΔR<sub>ON</sub> = 5Ω (typ.) for V<sub>DD</sub>-V<sub>EE</sub> = 18V
- ◆ Very Low Quiescent Power Dissipation under all Digital Control Input and Supply Conditions: 1μW typ. @ V<sub>DD</sub>-V<sub>SS</sub> = V<sub>DD</sub>-V<sub>EE</sub> = 10V
- ◆ Binary Address Decoding on Chip

### DESCRIPTION

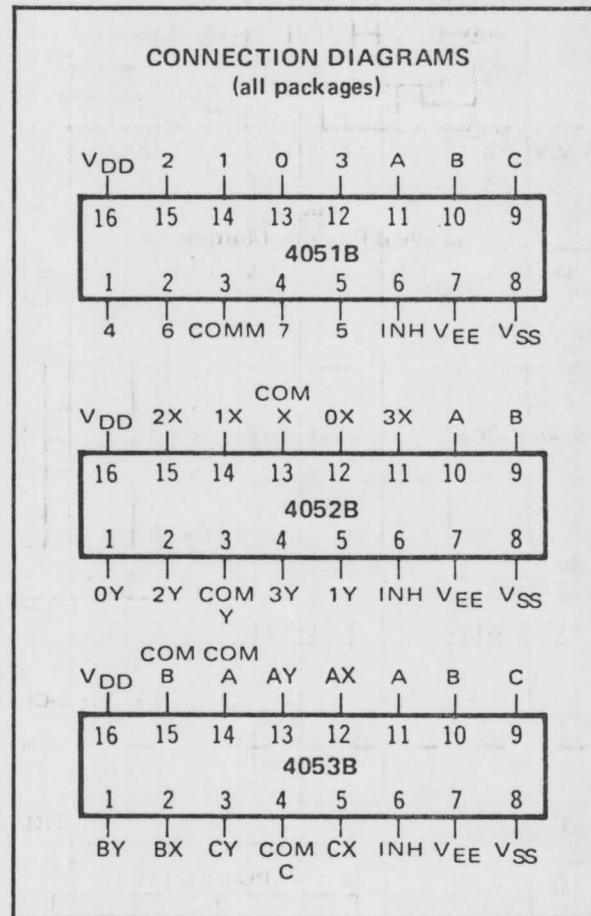
The 4051B, 4052B, and 4053B are Digitally-Controlled Analog Switches having low ON-impedance and very low OFF leakage current. Control of analog signals up to 15V<sub>p-p</sub> can be achieved by digital signal amplitudes of 3 to 15V. For example, if V<sub>DD</sub> = +5V, V<sub>SS</sub> = 0V, and V<sub>EE</sub> = -5V, analog signals from -5V to +5V can be controlled by digital inputs of 0 to 5V. The multiplexer circuits dissipate extremely low quiescent power over the full V<sub>DD</sub> - V<sub>SS</sub> and V<sub>DD</sub> - V<sub>EE</sub> supply-voltage ranges, independent of the logic state of the control signals. When a logic "1" is present at the Inhibit input terminal all channels are OFF.

4051B is a Single 8-Channel Multiplexer having three binary Control inputs, A, B, and C, and an Inhibit input. The three binary signals select 1 of 8 channels to be turned ON and connect the input to the output.

4052B is a Differential 4-Channel Multiplexer having two binary Control inputs, A and B, and an Inhibit input. The two binary input signals select 1 of 4 pairs of channels to be turned on and connect the differential analog inputs to the differential outputs.

4053B is a Triple 4-Channel Multiplexer having three separate digital Control inputs, A, B, and C and an Inhibit input. Each control input selects one of a pair of channels which are connected in a single-pole double-throw configuration.

When the devices are used as demultiplexers, the "CHANNEL IN/OUT" terminals are the outputs and the "COMMON OUT/IN" terminal(s) is (are) the input(s).



### RECOMMENDED OPERATING CONDITIONS

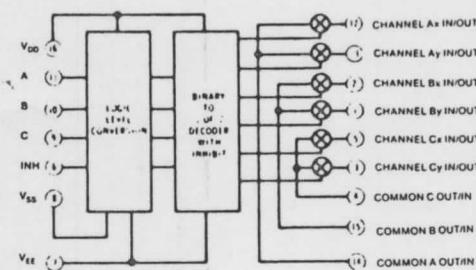
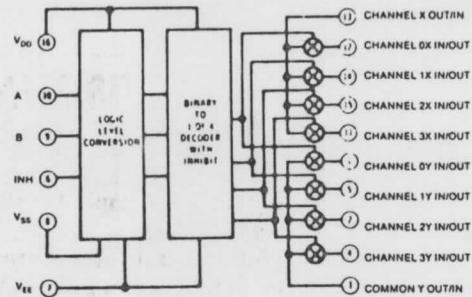
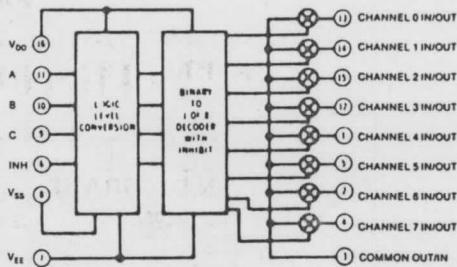
For maximum reliability:

DC Supply Voltage      V<sub>DD</sub> - V<sub>SS</sub>      3 to 15      Vdc  
                            V<sub>DD</sub> - V<sub>EE</sub>      3 to 15      Vdc

Operating Temperature      T<sub>A</sub>  
C, D, F, H Device      -55 to +125      °C  
E Device      -40 to +85      °C

NOTE: There are no restrictions on the relative magnitudes of V<sub>SS</sub> and V<sub>EE</sub>, providing Absolute Maximum Ratings are observed.

## LOGIC DIAGRAMS



TRUTH TABLE

| INPUT STATES |   |   |   | "ON" CHANNELS |                                 |  |
|--------------|---|---|---|---------------|---------------------------------|--|
| INHIBIT      | C | B | A | 4051          | 4052                            | 4053   |
| 0            | 0 | 0 | 0 | 0             | O <sub>x</sub> , O <sub>y</sub> | c <sub>x</sub> , b <sub>x</sub> , a <sub>x</sub> |
| 0            | 0 | 0 | 1 | 1             | 1 <sub>x</sub> , 1 <sub>y</sub> | c <sub>x</sub> , b <sub>x</sub> , a <sub>y</sub> |
| 0            | 0 | 1 | 0 | 2             | 2 <sub>x</sub> , 2 <sub>y</sub> | c <sub>x</sub> , b <sub>y</sub> , a <sub>x</sub> |
| 0            | 0 | 1 | 1 | 3             | 3 <sub>x</sub> , 3 <sub>y</sub> | c <sub>x</sub> , b <sub>y</sub> , a <sub>y</sub> |
| 0            | 1 | 0 | 0 | 4             |                                 | c <sub>y</sub> , b <sub>x</sub> , a <sub>x</sub> |
| 0            | 1 | 0 | 1 | 5             |                                 | c <sub>y</sub> , b <sub>x</sub> , a <sub>y</sub> |
| 0            | 1 | 1 | 0 | 6             |                                 | c <sub>y</sub> , b <sub>y</sub> , a <sub>x</sub> |
| 0            | 1 | 1 | 1 | 7             |                                 | c <sub>y</sub> , b <sub>y</sub> , a <sub>y</sub> |
| 1            | * | * | * | NONE          | NONE                            | NONE   |

\* = Don't care

## ELECTRICAL CHARACTERISTICS

STATIC CHARACTERISTICS<sup>1</sup>

| PARAMETER  |                 | CONDITIONS   | $V_{SS}$<br>(Vdc) | $V_{DD}$<br>(Vdc) | $V_{EE}$<br>(Vdc) | $T_{LOW}^2$ |           | $+25^\circ C$ |            |           | $T_{HIGH}^2$ |            | Units      |
|--|-----------------|--|-------------------|-------------------|-------------------|-------------|-----------|---------------|------------|-----------|--------------|------------|------------|
|  |                 |  |                   |                   |                   | Min.        | Max.      | Min.          | Typ.       | Max.      | Min.         | Max.       |            |
| QUIESCENT<br>DEVICE CURRENT                                      | $I_{DD}$        | $V_{IN}=V_{SS}$ or $V_{DD}$<br>All valid input<br>combinations                       | 0                 | +5                | 0                 | —           | 5         | —             | 0.05       | 5         | —            | 150        | $\mu A/dc$ |
|  |                 |  | 0                 | +10               | 0                 | —           | 10        | —             | 0.1        | 10        | —            | 300        |            |
|  |                 |  | +5                | -5                |                   |             |           |               |            |           |              |            |            |
|  |                 |  | 0                 | +15               | 0                 | —           | 20        | —             | 0.2        | 20        | —            | 600        |            |
|  |                 |  | +7.5              | -7.5              |                   |             |           |               |            |           |              |            |            |
| MINIMUM INPUT<br>HIGH VOLTAGE<br>(Control and Inhibit<br>Inputs) | $V_{IH}$        | $V_{is}=V_{EE}$<br>$V_{os}=V_{DD}$<br>$I_{os}=10\mu A$                               | 0                 | 5                 | 0                 | —           | 3.5       | —             | 2.75       | 3.5       | —            | 3.5        | Vdc        |
|  |                 |  | 0                 | 10                | 0                 | —           | 7.0       | —             | 5.5        | 7.0       | —            | 7.0        |            |
|  |                 |  | 0                 | 15                | 0                 | —           | 11.0      | —             | 8.25       | 11.0      | —            | 11.0       |            |
| MAXIMUM INPUT<br>LOW VOLTAGE<br>(Control and Inhibit<br>Inputs)  | $V_{IL}$        | $V_{is}=V_{EE}$<br>$V_{os}=V_{DD}$<br>$I_{os}=10\mu A$                               | 0                 | 5                 | 0                 | 1.5         | —         | 1.5           | 2.25       | —         | 1.5          | —          | Vdc        |
|  |                 |  | 0                 | 10                | 0                 | 3.0         | —         | 3.0           | 4.5        | —         | 3.0          | —          |            |
|  |                 |  | 0                 | 15                | 0                 | 4.0         | —         | 4.0           | 6.75       | —         | 4.0          | —          |            |
| SWITCH INPUT/<br>OUTPUT LEAKAGE                                  | $I_{OFF}$       | $V_{IN}=V_{SS}$ or $V_{DD}$<br>$V_{is}=\pm 7.5Vdc$                                   | 0                 | +7.5              | -7.5              | —           | $\pm 100$ | —             | $\pm 0.01$ | $\pm 100$ | —            | $\pm 1000$ | nAdc       |
| Any channel OFF  | $I_{OFF}$       | $I_{inh} = 7.5Vdc$<br>$V_{is} = \pm 7.5Vdc$<br>4051B                                 | 0                 | +7.5              | -7.5              | —           | $\pm 400$ | —             | $\pm 0.08$ | $\pm 400$ | —            | $\pm 1000$ | nAdc       |
|  |                 |  |                   |                   |                   |             |           |               |            |           |              |            |            |
|  |                 |  |                   |                   |                   |             |           |               |            |           |              |            |            |
|  |                 |  |                   |                   |                   |             |           |               |            |           |              |            |            |
| ON-RESISTANCE  | $R_{ON}$        | $V_{IN}=V_{SS}$ or $V_{DD}$<br>$V_{EE} \leq V_{is} \leq V_{DD}$<br>$R_L = 10k\Omega$ | -7.5              | +7.5              | -7.5              | —           | 220       | —             | 125        | 280       | —            | 400        | $\Omega$   |
|  |                 |  |                   |                   |                   |             |           |               |            |           |              |            |            |
|  |                 |  |                   |                   |                   |             |           |               |            |           |              |            |            |
|  |                 |  |                   |                   |                   |             |           |               |            |           |              |            |            |
|  |                 |  |                   |                   |                   |             |           |               |            |           |              |            |            |
|  |                 |  |                   |                   |                   |             |           |               |            |           |              |            |            |
| ON-RESISTANCE<br>MATCH<br>(Same Package)                         | $\Delta R_{ON}$ | $V_{IN}=V_{SS}$ or $V_{DD}$<br>$V_{EE} \leq V_{is} \leq V_{DD}$<br>$R_L = 10k\Omega$ | -7.5              | +7.5              | -7.5              | —           | 310       | —             | 180        | 400       | —            | 590        | $\Omega$   |
|  |                 |  |                   |                   |                   |             |           |               |            |           |              |            |            |
|  |                 |  |                   |                   |                   |             |           |               |            |           |              |            |            |
|  |                 |  |                   |                   |                   |             |           |               |            |           |              |            |            |
|  |                 |  |                   |                   |                   |             |           |               |            |           |              |            |            |
|  |                 |  |                   |                   |                   |             |           |               |            |           |              |            |            |

NOTES: <sup>1</sup> Remaining Static Characteristics are listed under "4000B Series Family Specifications".

<sup>2</sup> In certain applications, the external load-resistor current may include both  $V_{DD}$  and signal-line components. To avoid drawing  $V_{DD}$  current when switch current flows into terminals 1, 4, 8, or 11, the voltage drop across the bidirectional switch must not exceed 0.8 volt (calculated from  $R_{ON}$  values shown).

No  $V_{DD}$  current will flow through  $R_L$  if the switch current flows into terminals 2, 3, 9, or 10. Failure to observe this condition may result in distortion of the signal.

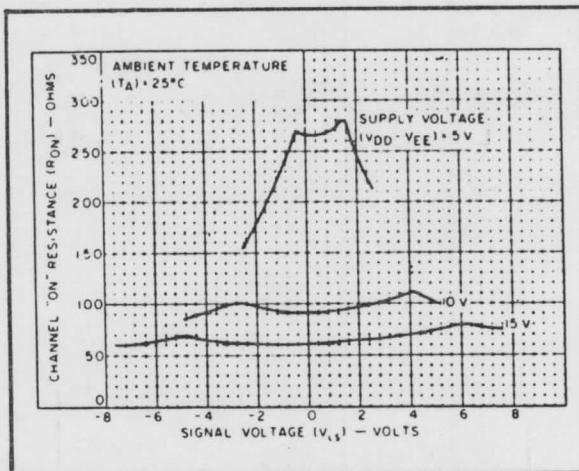
**SCL4051B, SCL4052B, SCL4053B**  
**ELECTRICAL CHARACTERISTICS (Continued)**

DYNAMIC CHARACTERISTICS ( $C_L = 50\text{pF}$ ,  $T_A = 25^\circ\text{C}$ )

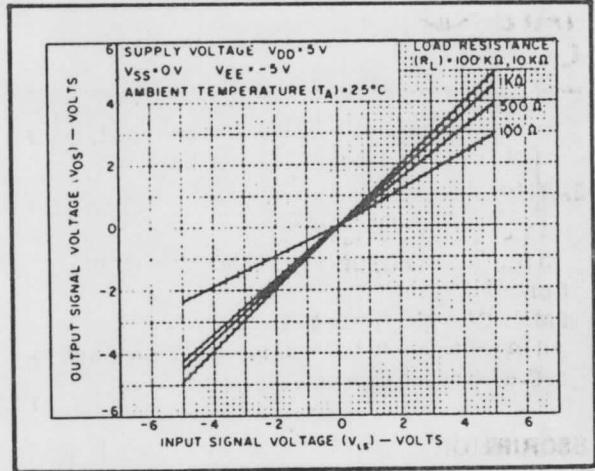
| PARAMETER  | CONDITIONS             | $V_{SS}$<br>(Vdc)  | $V_{DD}$<br>(Vdc)  | $V_{EE}$<br>(Vdc)                      | Min.                              | Typ.                       | Max.                                   | Units                                  |
|--|------------------------|--|--|--|-----------------------------------|----------------------------|--|--|
| <b>SIGNAL INPUTS (<math>V_{is}</math>) AND OUTPUTS (<math>V_{os}</math>)</b> |                        |  |  |  |                                   |                            |  |  |
| PROPAGATION DELAY TIME<br>Signal Input to Signal Output                      | $t_{PLH}$<br>$t_{PHL}$ | Inh = $V_{SS}$<br>$V_{IN} = V_{SS}$ or $V_{DD}$<br>$V_{is}$ = Square Wave<br>$R_L = 10\text{k}\Omega$  | 0<br>0<br>0  | 5<br>10<br>15                          | 0<br>0<br>0                       | -<br>-<br>-                | 30<br>15<br>12.5                       | 60<br>30<br>25                         |
| BANDWIDTH (-3dB)<br>(Sine Wave)  | BW                     | Inh = $V_{SS}$<br>$V_{IN} = V_{SS}$<br>or $V_{DD}$<br>$V_{is} = 5V_{pp}$<br>centered<br>@ 0.0Vdc   | $R_L$<br>$1\text{k}\Omega$<br>$10\text{k}\Omega$<br>$100\text{k}\Omega$<br>$1\text{M}\Omega$ | 0                                      | +5                                | -5                         | -<br>54<br>40<br>38<br>37              | -<br>-<br>-<br>-                       |
| INSERTION LOSS<br>(= $20 \log_{10} \frac{V_{os}}{V_{is}}$ )                  |                        | Inh = $V_{SS}$<br>$V_{IN} = V_{SS}$<br>or $V_{DD}$<br>$V_{is} = 5V_{pp}$<br>centered<br>@ 0.0Vdc   | $R_L$<br>$1\text{k}\Omega$<br>$10\text{k}\Omega$<br>$100\text{k}\Omega$<br>$1\text{M}\Omega$ | 0                                      | +5                                | -5                         | -<br>2.3<br>0.2<br>0.1<br>0.05         | -<br>-<br>-<br>-                       |
| SIGNAL DISTORTION<br>(Sine Wave)   |                        | Inh = $V_{SS}$<br>$V_{IN} = V_{SS}$ or $V_{DD}$<br>$V_{is} = 5V_{pp}$<br>centered<br>@ 0.0Vdc<br>$f_s = 1.0\text{kHz}$<br>$R_L = 10\text{k}\Omega$ | -7.5<br>-5<br>-2.5   | +7.5<br>+5<br>+2.5                     | -7.5<br>-5<br>-2.5                | -<br>-<br>-                | 0.1<br>0.2<br>1.0                      | -<br>-<br>-                            |
| FEEDTHROUGH<br>(-40dB)   |                        | Inh = $V_{SS}$<br>$V_{IN} = V_{SS}$<br>or $V_{DD}$<br>$V_{is} = 5V_{pp}$<br>centered<br>@ 0.0Vdc   | $R_L$<br>$1\text{k}\Omega$<br>$10\text{k}\Omega$<br>$100\text{k}\Omega$<br>$1\text{M}\Omega$ | 0                                      | +5                                | -5                         | -<br>1250<br>140<br>18<br>2            | -<br>-<br>-<br>-                       |
| CROSSTALK (-40dB)<br>Between two switches                                    |                        | Inh = $V_{SS}$<br>$V_{IN} = V_{SS}$ or $V_{DD}$<br>$V_{is} = 5V_{pp}$<br>centered<br>@ 0.0Vdc<br>$R_L = 1.0\text{k}\Omega$                         |  | 0                                      | +5                                | -5                         | -<br>1.0                               | -<br>MHz                               |
| CAPACITANCE<br>Input   | $C_{is}$               | Inh = $V_{DD}$   |  | 0                                      | +5                                | -5                         | -<br>5                                 | -<br>pF                                |
| Common   | $C_{os}$               | 4051B<br>4052B<br>4053B  |  | 0                                      | +5                                | -5                         | -<br>30<br>18<br>10                    | -<br>-<br>-                            |
| Feedthrough  | $C_{ios}$              |  |  | 0                                      | +5                                | -5                         | -<br>0.2                               | -<br>pF                                |
| <b>CONTROL INPUTS</b>  |                        |  |  |  |                                   |                            |  |  |
| PROPAGATION DELAY TIME <sup>1</sup><br>Turn on                               | $t_{PLH}$<br>$t_{PHL}$ | Inh = $V_{SS}$<br>$V_{EE} \leq V_{IN} \leq V_{DD}$<br>$R_L = 10\text{k}\Omega$   | 0<br>0<br>0<br>0<br>-2.5<br>0  | +7.5<br>+15<br>+5<br>+10<br>+2.5<br>+5 | -7.5<br>0<br>-5<br>0<br>-2.5<br>0 | -<br>-<br>-<br>-<br>-<br>- | 160<br>120<br>225<br>160<br>400<br>360 | 320<br>240<br>450<br>320<br>800<br>720 |
| <b>INHIBIT INPUT</b>   |                        |  |  |  |                                   |                            |  |  |
| PROPAGATION DELAY TIME<br>Turn on  | $t_{PLH}$<br>$t_{PHL}$ | $V_{IN} = V_{SS}$ or $V_{DD}$<br>$V_{is} = V_{DD}$<br>$R_L = 10\text{k}\Omega$   | 0<br>0<br>0<br>0<br>-2.5<br>0  | +7.5<br>+15<br>+5<br>+10<br>+2.5<br>+5 | -7.5<br>0<br>-5<br>0<br>-2.5<br>0 | -<br>-<br>-<br>-<br>-<br>- | 160<br>120<br>200<br>160<br>400<br>360 | 320<br>240<br>400<br>320<br>800<br>720 |
| INHIBIT RECOVERY TIME <sup>2</sup>   | $t_{rel}$              | $V_{IN} = V_{SS}$ or $V_{DD}$<br>$V_{EE} \leq V_{IN} \leq V_{DD}$<br>$R_L = 10\text{k}\Omega$  | 0<br>0<br>0<br>0<br>-2.5<br>0  | +7.5<br>+15<br>+5<br>+10<br>+2.5<br>+5 | -7.5<br>0<br>-5<br>0<br>-2.5<br>0 | -<br>-<br>-<br>-<br>-<br>- | 150<br>80<br>200<br>105<br>300<br>225  | 300<br>160<br>400<br>210<br>600<br>450 |

Notes: <sup>1</sup> Channel Overlap time - interval following change of control input during which two channels may be ON simultaneously.

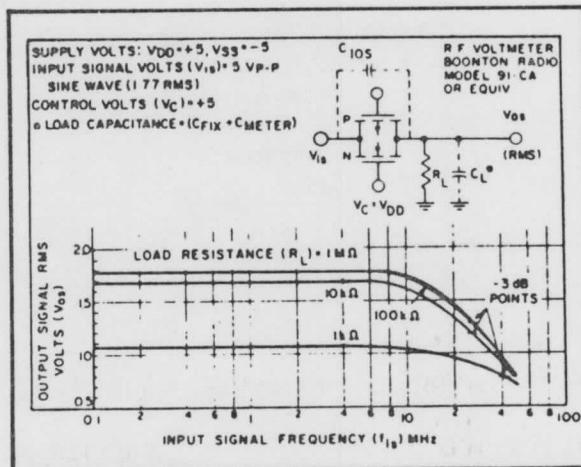
<sup>2</sup> Interval following removal of Inhibit during which channel information is invalid.



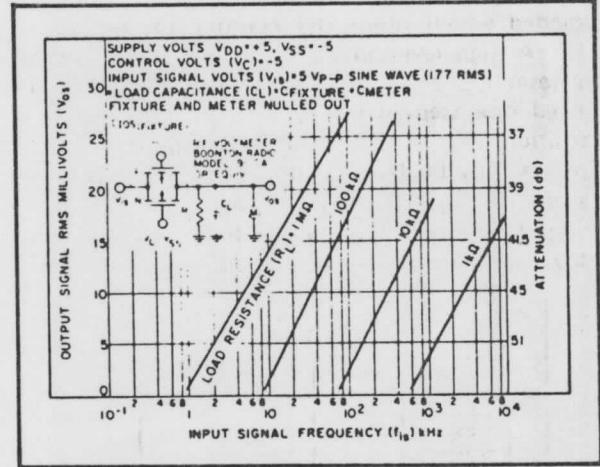
Typical Channel "ON" resistance vs. signal voltage



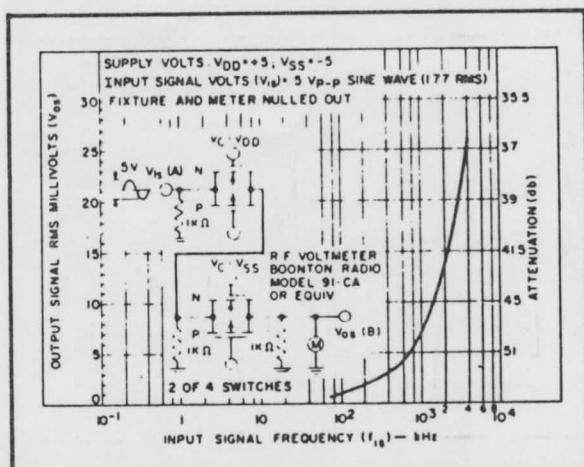
Typical "ON" characteristics



Typ. switch frequency response - switch "ON"



Typ. feedthru vs. freq. - switch "OFF"



Typ. crosstalk between switch circuits in the same package

